Hammer

# 1985 FISHERIES HABITAT AND AQUATIC ENVIRONMENT MONITORING REPORT
# BITTERROOT NATIONAL FOREST

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In cooperation with

MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS



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1985 FISHERIES HABITAT AND AQUATIC ENVIRONMENT MONITORING REPORT-BITTERROOT NATIONAL FOREST

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## INTRODUCTION

Accelerated rates of surface erosion and mass wasting resulting from logging or roading have the potential to increase levels of sediment delivery to forest streams beyond "natural" or background levels. Streams vary in their abilities to transport increased sediment loads, depending on factors such as channel gradient, discharge, bed roughness, and sinousity. These factors influence how much sediment delivered to a stream may be transported out of the system during high-flow periods when the additional energy necessary to carry that load is available. As peak flows recede, this energy becomes decreasingly available, and deposition of the suspended or bedload sediment load occurs. Once deposited, sediment remains as part of the substrate until sufficient stream energy develops to dislodge the sediment and transport it downstream. Sediment is a naturally occurring material in stream systems. If supply of sediment to the stream exceeds the streams ability to transport sediment from the system, the existing equilibrium is changed and the result is additional storage of sediment within or on the stream substrate.

Adverse effects of sediment on biological communities has been well documented. Public concerns about the effects of accelerated levels of Forest originated sediment has raised the priority for gathering additional data on sediment and its effects on biological communities. Substrate sediment measurements, and the response by both the invertebrate community and the fish population are the focus of this monitoring effort.

One method of evaluating and rating the degree of substrate sediment deposition within a stream reach is by measuring the relative "embeddedness" of that substrate. Embeddedness is defined as: The degree that larger streambed particles are surrounded or covered by fine sediment.

Embeddedness levels are often used as indices in evaluating a channel substrate's suitability for biotic productivity, because embeddedness has been demonstrated to be a key characteristic in describing fish habitat suitability. As the amount of deposited sediment (embeddedness) increases, the quality of instream cover provided by the channel substrate decreases. In addition, embeddedness levels have been used to evaluate the substrate's suitability for spawning, egg incubation, and macroinvertebrate habitat.

Embeddedness is also used to translate the amount of sediment delivered to a stream to fish consequences as displayed in the Forest Service R1/R4 Sediment Fish Response Model used to evaluate alternatives of the Bitterroot Forest Plan.

## OBJECTIVES

Sampling of embeddedness levels, macroinvertebrate communities, and fish populations were initiated during the summer of 1985 with the goal of providing data on the following subject areas over the next several years:

1) Gather baseline embeddedness data for future comparisons of embeddedness trends over time in drainages impacted in the past or in drainages with development proposed in the future.

2) Compare embeddedness levels by morphological position (i.e. riffles, runs, pool tailouts).

3) Evaluate stream embeddedness differences between relatively developed and relatively undeveloped drainages. Streams to be compared will be selected on the basis of similar geology and gradients, and similar hydrologic characteristics.

4) Compare fish population response to different levels of embeddedness on study streams. The Montana Department of Fish, Wildlife, and Parks has the primary lead for gathering field data on fish populations.

    Evaluate other habitat components (i.e. pool quantity, cover) that may compensate for sediment increases as indicated by fish populations.

5) Compare macroinvertebrate community composition and biomass in riffles as embeddedness levels change.

This project will be supported by hydrologic and sediment transport data gathered by Forest hydrologists.

Null hypotheses to be tested include:

Ho1 There are no differences in stream bottom embeddedness or percentage of free matrix particles in streams draining developed versus undeveloped watersheds where sampling watersheds have similiar geology and stream sampled are of similiar size and gradient. Specifically, to evaluate Meadow Creek (Developed) versus Tolan Creek (Undeveloped) and Martin Creek (Developed) versus Moose Creek (Undeveloped).

Ho2 There are no differences in fish populations in the above compared pairs of streams that cannot be explained by other habitat variables

Ho3 There is no change in stream embeddedness levels in monitored streams as drainages are developed.

Ho4 There is no change in invertebrate community as reflected by species dominance, abundance or biomass in monitored streams as the drainages are developed.

Ho5 There is no change in the fish populations of monitored streams as the drainages are developed.

Ho6 There are no differences in embeddedness found in the different riffles of the same stream reach; i.e. that any riffle is the same as another in the same stream reach.

Ho7 There are no differences between percentage embeddedness expressed by the extraction/individual particle measurement technique and the surface ocular measurement techniques

## SAMPLE DESIGN

Two approaches were used to evaluate embeddedness and its effects on fisheries habitat. One approach was be to compare sites on pairs of streams with similar geology, stream size, and gradient with the major variable being whether past forest development has taken place in the drainage. The objective of this evaluation was to determine whether substantial embeddedness differences exist on developed and undeveloped drainages. The interpretation of this evaluation is general in nature, but will provide scoping information as to the magnitude of sediment embeddedness differences resulting from development if the differences are severe.

The second approach, and the primary focus of the project, is to establish long-term monitoring stations on a number of streams draining watersheds of different geologic origin. Many of these streams have proposed land management activities scheduled in the next decade. The other streams will be used as controls. Most of the objectives listed above will be met and hypotheses will be tested with this portion of the monitoring effort.

Four streams were selected on the Bitterroot National Forest for use in a paired analysis. Each pair consisted of an undeveloped and developed watershed with similar geology, landtypes, and hydrologic character (see Appendix I). Embeddedness sampling was conducted at all locations during low flow conditions (mid-July thru October). Sample sites consisting of riffle, run, or pool tailouts selected from the lowest gradient class available on that stream within the Forest boundary (see Appendix II). Comparisons made between paired streams were restricted to those stream reaches having similiar gradients.

Paired Streams for Comparisons of Embeddedness and Its Implications

| Developed Drainage | Undeveloped Drainage | Geologic Type |
|---|---|---|
| Meadow Creek | Tolan Creek | Soft Granitic |
| Martin Creek | Moose Creek | Moderate Granitics |

The other streams selected for monitoring stations were chosen for a number of reasons, including (1) the drainage represented a previously undeveloped drainage of a relatively pure geologic type; (2) a land management project of potential biological or political significance was proposed; and (3) previous long-term hydrologic stations had been established with corresponding sediment delivery and streamflow data available.

Other Streams Selected for Embeddedness,
Invertebrate, and Fish Population Evaluations

| Stream | Forest | Significance |
|---|---|---|
| Sleeping Child Creek | Bitterroot | Sensitive granitic, previously undeveloped |
| Gold Creek | Bitterroot | Representative of belt series, previously undeveloped |

## EMBEDDEDNESS PROCEDURES, ANALYSIS, AND DOCUMENTATION METHODS

Methods for sampling embeddedness were adapted from Burns (1984).

Sampling was conducted at each location by randomly throwing a 60 centimeter diameter steel hoop into an area of the stream predetermined and boundary delineated as representing one of the three morphological positions (riffle, run, or pool tailout)(Figure 1). Samples were only taken if the area within the hoop met the following criteria:

1) Hoop must fall in the center one-third of the active channel or where bank deposition is not obvious

2) The hoop or part of the hoop is not in an eddy caused by either a pool or large boulder.

In sites meeting the above criteria, a 30-centimeter transparent ruler affixed to a plexiglas frame was used to measure each free matrix particle (non-embedded) and embedded matrix particle between 4.5 and 30.0 centimeters in diameter within the area of the hoop. Starting at one side of the hoop, all free matrix particles were systematically removed and measured for the greatest diameter, perpendicular to the plane of embeddedness (d1). Next, all embedded matrix particles were be removed and measured for both (d1) and (d2), the distance along (d1) which is covered by fine sediment (< 6.3 mm diameter) or "embedded" in the stream bottom (Figure 2).

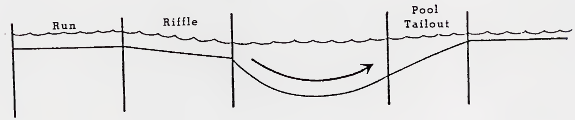


Figure 1. Hypothetical stream profile indicating morphological positions sampled for embeddedness.

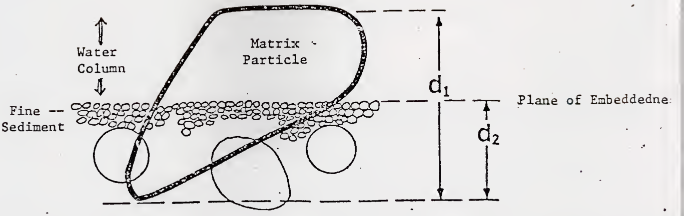


Figure 2. Diagram indicating the embeddedness measurements of an individual substrate rock.

Each matrix particle to be measured was removed by grasping it with the tips of the thumb and fingers at the plane of embeddedness. This hand position, which marks the plane of embeddedness, was maintained while transferring the particle to the plexiglas measuring device. Occasionally, changes in hand position were required to remove large particles. In such cases, other indicators (i.e. algal stains) or methods of marking the plane of embeddedness were used.

Measurements of (d1) and (d2) were taken by placing the particle against the plexiglas plate holding the transparent ruler, while insuring the end of the particle was firmly placed up against the adjacent (at right angle to) plexiglas plate. From this alignment, using the maintained finger position described above, the measurements (d1) and (d2) were read (Figure 3).

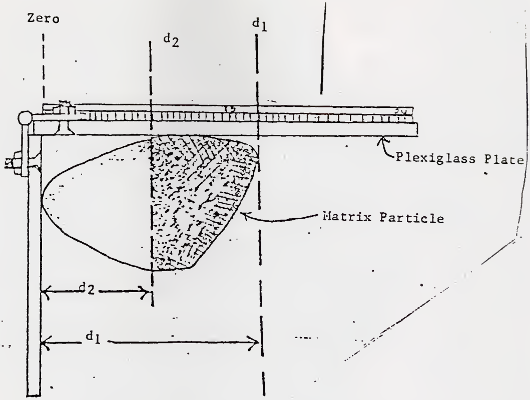


Figure 3. Diagram of substrate rock placed on embeddedness measurement instrument.

Percent embeddedness of each matrix particle measured was calculated using the following formula:

$$E = d2 / d1$$

Where: E = % Embedded

d1 = The longest diameter of a matrix particle (between 4.5 and 30.0 cm) perpendicular to the plane of embeddedness.

d2 = The distance along (d1) covered by fine sediment (<6.3 mm diameter) or "embedded" in the stream bottom.

The hoop was repeatedly thrown until a total of 100 matrix particle measurements were made at each morphological position. After taking 100 measurements, all remaining matrix particles inthe last hoop were measured to avoid any bias against selecting the upper or larger particles. All particles wholly or partially within the hoop were measured. Measurement of particles continue to a depth where particles are no longer in contact with the water column, i.e. where intersticial spaces permit free flowing water to contact the particles. This procedure normally results in all particles at least partially free of contact with fines being measured for embeddedness(Figure 4).

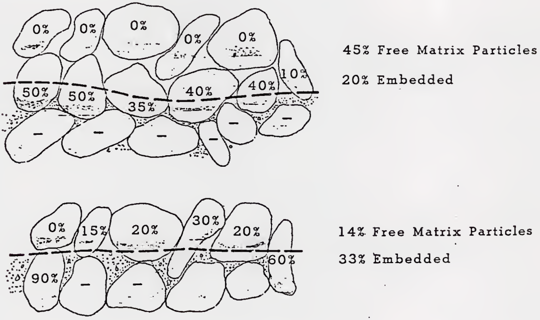


Figure 4. Diagram of two hypothetical stream substrate crossections with two different levels of embeddedness.

A linear profile of each sample site along the thalweg was established using permanent elevation reference points (Appendix ). A channel crossection was established at each site (Appendix ). Boundaries of each station were marked with flagging and a photo record of each station and its boundaries were recorded. Permanent reference points with distances and bearings to stations boundaries were recorded. Site locations were identified on aerial photos and on 2.64"/mile quads. Site and station documentation is kept in individual file folders in the office of the Zone Fisheries Biologist.

## MACROINVERTEBRATE PROCEDURES, ANALYSIS AND DOCUMENTATION

### METHODS

Macroinvertebrates were collected at the riffle stations for each site identified for embeddedness analysis. Five samples of 1 square foot were collected from within the site boundaries using a modified Surber Sampler. Samples were collected during a 2-week period in the fall to provide consistency of samples for future comparison. Individual samples were labeled and preserved in 70 percent alcohol. During 1985, 35 samples from seven stations on six streams were collected and forwarded to Dr. Mangum(Mangum, 1986).

### ANALYSIS

Analysis was completed by Dr. Fred Mangum, Forest Service Aquatic Lab, Provo, Utah. He provided qualitative and quantitative analysis, including confidence limits with standard deviation, standard error, and coefficient of variation for replications. He also assisted in an analysis of the relative embeddedness with community structure and biomass of invertebrates by assigning taxa to ecological niches relative to sediment deposition (Figure 5).

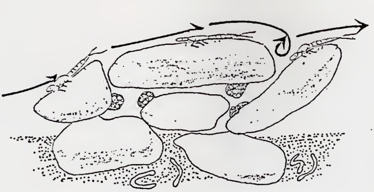


Figure 5. Diagram of hypothetical stream crossection indicating the distribution of a variety of insect groups within or on the substrate.

## FISH POPULATION PROCEDURES, ANALYSIS AND DOCUMENTATION

### PROCEDURE

Fish population estimates were completed in the immediate vicinity of embeddedness sampling sites. Additional sampling sites may be added on study drainages to evaluate spatial distribution changes, fish movement patterns, and habitat selection by indigenous fish species. The sampling schedule began with fish population estimates in August and September, 1985.

One of three proven fish population estimating techniques have been used. Two of the methods use Chapman's modification of the Peterson formula described by Ricker, 1975. Variance of the estimates have been estimated using Chapman's formula also described in Ricker, 1975. Both of these estimators of population abundance involve marking and recapturing "runs", one method uses electrofishing gear and the other method uses hook and line for marking runs, and snorkel and mask for recapture runs. The third method utilizes electrofishing gear for two-sample population estimates described by Seber, 1973.

Due to the statistical consideration of acquiring an adequate sample size of fish for good population estimates, study sections required greater length than the embeddedness stations selected by the Forest Service.

Sample stations have been permanently marked with steel fence posts on the lower boundary of the section and use local witness geology and/or topography to cross reference the lower boundary. Section length has been included as part of the section description.

## RESULTS

### Meadow Creek

#### Site Description

Meadow Creek is a tributary to the East Fork of the Bitterroot River managed by the Sula Ranger District. The lower study site (Figures 6-8) has a drainage area of 18.9 square miles with an existing road density of 3.63 miles per section and 68.6 miles of road in the study area.. Table 1 details the history of roading in the drainage upstream from the study site. Study site 1 (lower) is located in T2N, R18W, N1/4Sec. 36. Site 1 is located in a type C channel with an overall surface gradient during summer flows of 2.8%. Study site 2 (upstream) is Located in T1N, R18W, NE1/4 Sec. 10, is in a C type channel with an overall surface gradient of 1.2 percent. Two riffles and one pool tailout were selected for study. Active channel width was 17-21 (mean=19) feet at the study site.

Table 1. History of road development in the Meadow Creek drainage

| Year | | Miles |
|---|---|---|
| 1950-1952 | | 7.2 |
| 1954 | | 2.1 |
| 1956-1958 | | 8.2 |
| 1963 | | .1 |
| 1966 | | 7.0 |
| 1967 | | 16.0 |
| 1968 | | 13.2 |
| 1969 | | 11.7 |
| 1973 | | .8 |
| 1976 | | 2.3 |
| | Total | 68.6 |

#### Embeddedness Results

Table 2 displays the 1985 embeddedness results. Mean embeddedness in the pool tailout was 41% while the riffles had significant (.05) embeddedness differences, one having embeddedness of 32% while the other site had a value of 42% (Table 3). The free matrix particles reflected this embeddedness difference, having values of 30.3% and 8.1% respectively.


Figure 6. Location of embeddedness sites 1 and 2 in Meadow Creek drainage.

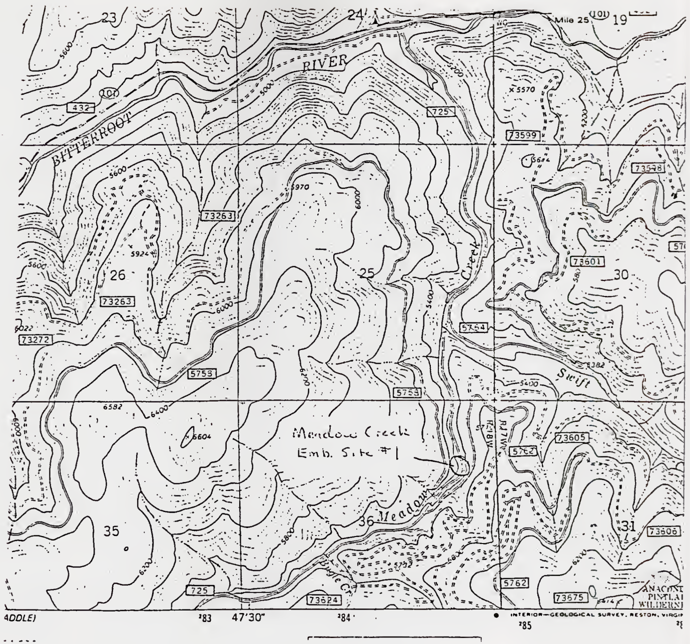


Figure 7. Location of Meadow Creek Site 1.

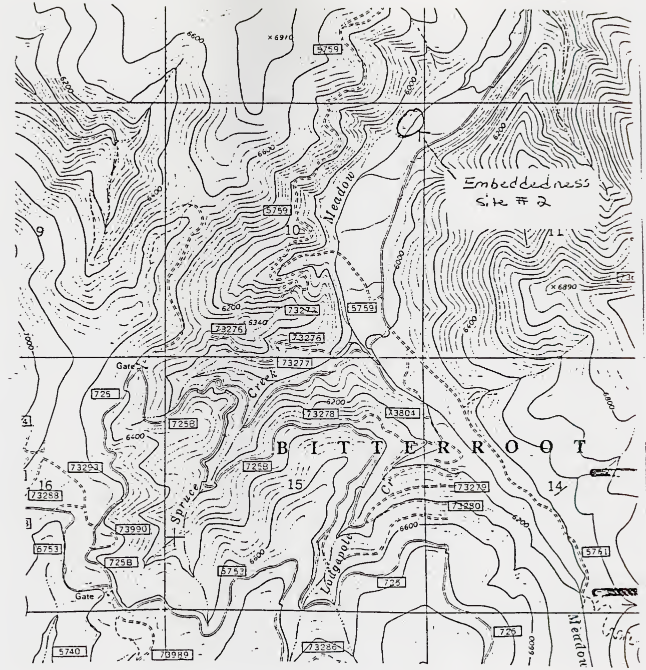


Figure 8. Location of Meadow Creek Site 2.

Table 2. Embeddedness and free matrix values for 1985 samples for two riffles and one pool tailout on Meadow Creek, Sula Ranger District.

| STREAM | SITE | STA. | TYPE | % GRAD. | N | % FREE | MEAN | STD.DV. | VARIANCE |
|---|---|---|---|---|---|---|---|---|---|
| MEADOW CREEK | 1 | A | RIFFLE | -2.0 | 111 | 8.1 | .4232 | .2029 | .0412 |
| MEADOW CREEK | 2 | A | RIFFLE | -2.4 | 99 | 30.3 | .3219 | .2659 | .0707 |
| MEADOW CREEK | 2 | B | POOL T. | +7.0 | 105 | 19.0 | .4126 | .2553 | .0652 |

Table 3. Statistical comparison of riffles embeddedness observed in two riffles on Meadow Creek using T-test..

| Stations Compared | Results | Two Tailed Probability |
|---|---|---|
| Station A Site 1<br>Station A Site 2 | Significant Difference<br>at .05 level | .002 |

Macroinvertebrate Results

Analysis indicates a population made up to taxa common to clean water, with the exception of large numbers of <u>Ephemerella inermis</u> (5000/m2), and Oligochates(4700/m2) which are tolerant to sediment which are considered to be warning numbers. Taxa requiring sediment free substrate made up 36% of the taxa, less than 10% of the numbers, but 26% of the biomass. Sediment dwelling species composed 26% of the taxa, 43% of the numbers, and 41% of the biomass. Standing crop was relatively high at 7 gms/m2, which is considerably higher than the 1-3.3 gms/m2 sampled at other sites in the stream from 1978-1984 (Mangum, 1986)

Fish Populations

Table 4 provides the fish population summary for Meadow Creek sampling during 1985.

Table 4. Fish population estimates for a 300 meter length of Meadow Creek during 1985.

| STREAM | LOCATION | SIZE CLASS | ALL TROUT | WS CUTTHROAT | OTHER TROUT | WHITEFISH |
|---|---|---|---|---|---|---|
| MEADOW CR | SITE 2 | TOT.POP. | 254 | 123 | 131 | - |
| - | - | 4"-5.9" | 121 | 52 | 69 | - |
| - | - | 6"+ | 133 | 71 | 62 | - |

<u>Tolan Creek</u>

Site Description

Tolan Creek is a tributary to the East Fork of the Bitterroot River managed by the Sula Ranger District. The study site (Figures 9-10) has a drainage area of 18.5 square miles with 21.2 miles of road and an existing road density of 1.15 miles per section. Table 5 details the history of roading in the drainage upstream from the study site. The study site is located in T1N, R19W, NE1/4 Sec 24. Site 1 is located in a type C channel with an overall surface gradient during summer flows of 1.4% and Site 2 has a water surface gradient of 0.8%. A riffle, run and pool tailout were selected for study. Active channel width was 18-20 (mean= 19) feet at the study site.

Table 5. History of roading in the Tolan Creek drainage.

| Year | Miles |
|---|---|
| 1956 | .2 |
| 1969 | 10.1 |
| 1978 | 9.6 |
| 1981 | 1.3 |
| | Total 21.2 |

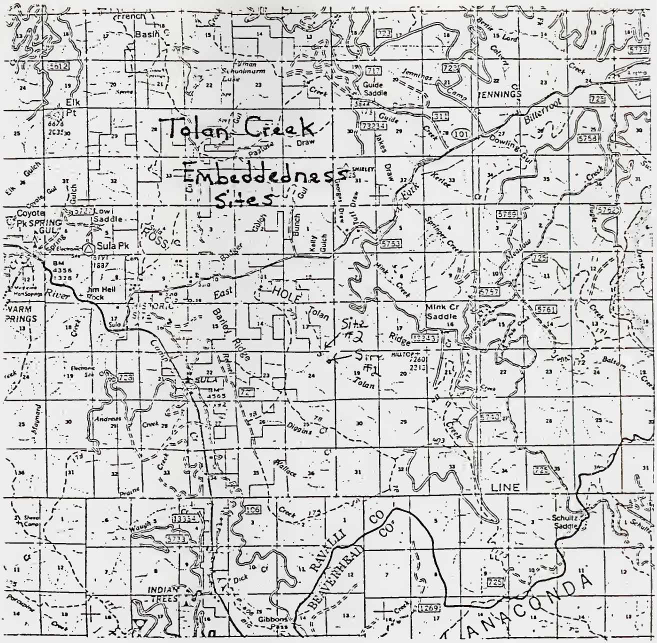


Figure 9. Vicinity map of Tolan Creek embeddedness site locations.

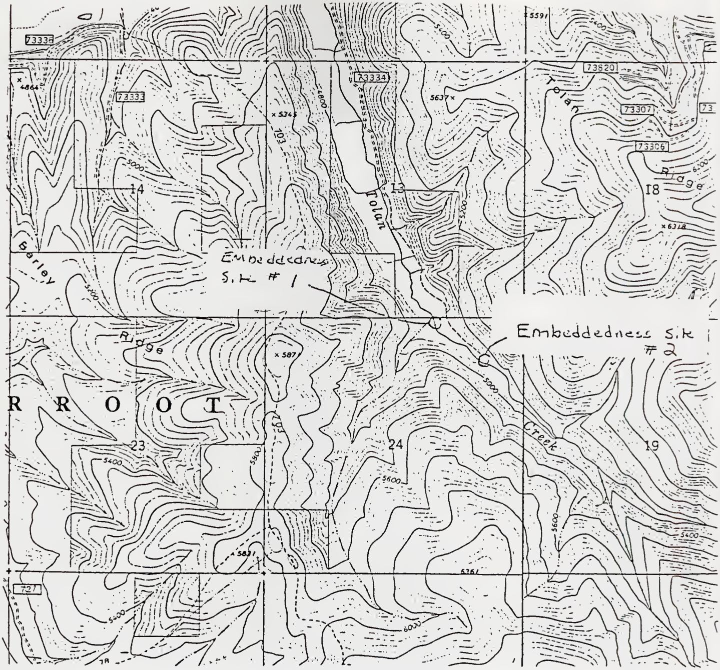


Figure 10. Location of Tolan Creek Embeddedness sites 1 and 2.

Embeddedness Results

Table 6 details the embeddedness data for 1985 in Tolan Creek. Values for the riffle, run and pool tailout were 32%, 33%, and 51% respectively. Free matrix particle values correlated inversely with the embeddedness values, being 18%, 13%, and 4% respectively. The high embeddednesss and low free matrix particle value for the pool tailout were the most extreme embeddedness found in any of the Bitterroot National Forest sites or stations in 1985.

Table 6. Embeddedness and free matrix values for 1985 samples for a riffle, run, and pool of Tolan Creek on the Sula Ranger district.

| STREAM | SITE | STA. | TYPE | % GRAD. | N | % FREE | MEAN | STD.DV. | VARIANCE |
|---|---|---|---|---|---|---|---|---|---|
| TOLAN CREEK | 1 | A | RIFFLE | -2.4 | 110 | 18.0 | .3208 | .2238 | .0501 |
| TOLAN CREEK | 1 | B | RUN | -0.6 | 113 | 13.3 | .3346 | .2171 | .0471 |
| TOLAN CREEK | 2 | A | POOL T. | +2.4 | 113 | 3.5 | .5057 | .1990 | .0398 |

Invertebrate Results

Despite relatively high embeddedness values, the invertebrate community displayed a community that has a high (51%) of the biomass made of taxa requiring a clean rock interstices, while only 22% were of taxa classed as sediment tolerant. 33% of the community numbers were made up of species moderately tolerant to sediment, while 42% were sediment tolerant species. Mangum (1986) considers the community near its potential(BCI=96), while noting that E. inermis and sediment dwelling oligochates were relatively numerous.

Fish Population Results

Table 7. Fish population estimates for a 300 meter length of Tolan Creek during 1985.

| STREAM | LOCATION | SIZE CLASS | ALL TROUT | WS CUTTHROAT | OTHER TROUT | WHITEFISH |
|---|---|---|---|---|---|---|
| TOLAN CR | SITE 1&2 | TOT. POP. | 163 | 114 | 49 | - |
| - | - | 4"-5.9" | 116 | 84 | 32 | - |
| - | - | 6"+ | 47 | 30 | 17 | - |

## Martin Creek

Site Description

Martin Creek is a tributary to the East Fork of the Bitterroot River managed by the Sula Ranger District. The study site (Figures 11-12) has a drainage area of 6.8 square miles with 28.8 miles of road or an existing road density of 4.24

miles per section. Table 8 details the history of roading in the drainage upstream from the study site. The study site is located in T3N, R18W, Sw1/4Sec.22. The site is located in a type C channel with an overall surface gradient during summer flows of 1.8%. A riffle, run and pool tailout were selected for study. Active channel width was 15.5 feet at the study site.

Table 8. History of roading in the Martin Creek drainage

| Year | | Miles |
|---|---|---|
| 1950 | | 1.5 |
| 1960 | | 15.8 |
| 1962 | | 7.5 |
| 1973 | | .2 |
| 1976 | | 3.8 |
| | Total | 28.8 |


Figure 11. Vicinity map of Martin Creek embeddedness sites.


Figure 12.- Location map of Martin Creek embeddedness site.

## Embeddedness Results

Table 9 details the embeddedness and free matrix particle values for 1985 sampling on Martin Creek. The embeddedness values ranging from 22 to 30 percent are moderately low, while the free matrix values are relatively high for the sites and stations sampled on the Bitterroot in 1985. This indicates low retention of substrate sediment in Martin Creek at the present time in all morphological positions of the stream.

Table 9. Embeddedness and free matrix values for 1985 samples for a riffle, run, and pool tailout on Martin Creek, Sula Ranger District.

| STREAM | SITE | STA. | TYPE | % GRAD. | N | % FREE | MEAN | STD.DV. | VARIANCE |
|---|---|---|---|---|---|---|---|---|---|
| MARTIN CREEK | 1 | A | RIFFLE | -0.5 | 102 | 28.4 | .2226 | .1915 | .0367 |
| MARTIN CREEK | 1 | B | RUN | +1.0 | 114 | 36.0 | .2842 | .2637 | .0695 |
| MARTIN CREEK | 1 | C | POOL T. | +5.0 | 107 | 32.7 | .3034 | .2691 | .0724 |

Macroinvertebrate Results

Despite the low embeddedness value found in the riffle site (22%), the invertebrate community did not display the community structure that would be expected. As Mangum (1986) describes, "clean water macroinveretbrate taxa were not abundant". 30% of the taxa, 54% of the numbers, and 31% of the community biomass was composed of sediment tolerant taxa. The taxa requiring clean intersticices made up 27% of the taxa, 9% of the numbers, and 16% of the biomass. Mangum (1986) indicates the BCI value reflects the ecosystem is in good condition, but could be better.

Fish Population Results

Table 10. Fish population estimates for a 300 meter length of Martin Creek during 1985.
1985.

| STREAM | LOCATION | SIZE CLASS | ALL TROUT | WS CUTTHROAT | OTHER TROUT | WHITEFISH |
|---|---|---|---|---|---|---|
| MARTIN CR | SITE 1 | TOT. POP. | 168 | 168 | - | - |
| " | " | 4"-5.9" | 70 | 70 | - | - |
| " | " | 6"+ | 98 | 98 | - | - |

Moose Creek

Site Description

Moose Creek is a tributary to the East Fork of the Bitterroot River managed by the Sula Ranger District. The study site (Figures 13-14) has a drainage area of 15.5 square miles with 4.3 miles of road with a road density of .28 miles of road per section. Table 11 details the roading history in the Moose Creek drainage. The study site is located in T3N, R17W, NE1/4Sec.33. The site is located in a type C channel with an overall surface gradient during summer flows of 1.6%. Two riffles, a run and a pool tailout were selected for study. Active channel width was 24-25 (mean=24.5) feet at the study site.

Table . Roading history of the Moose Creek Drainage.

| Year | Miles |
|---|---|
| 1925 | 2.1 |
| 1960 | 2.2 |


Figure 13. Vicinity map of Moose Creek embeddedness site.

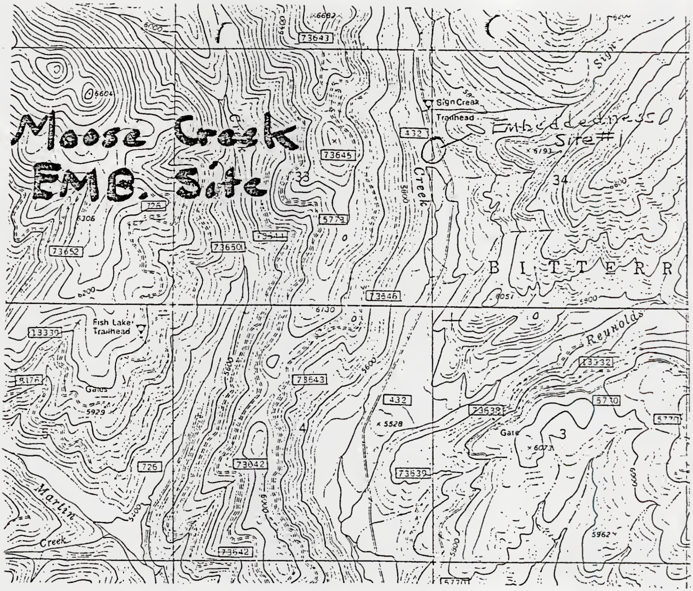


Figure 14. Location map of Moose Creek embeddedness site.

Embeddedness Results

Table 12 displays the embeddedness and free matrix particle values for 1985 sampling of Moose Creek. The results indicate moderate embeddedness with high variability in the amount of free matrix particles present.

Table 12. Embeddedness and free matrix values for 1985 samples for 2 riffles, one run and a pool tailout on Moose Creek, Sula Ranger District.

| STREAM | SITE | STA. | TYPE | % GRAD. | N | % FREE | MEAN | STD.DV. | VARIANCE |
|---|---|---|---|---|---|---|---|---|---|
| MOOSE CREEK | 1 | A | POOL T. | +3.4 | 106 | 13.2 | .3659 | .2181 | .0476 |
| MOOSE CREEK | 1 | B | RIFFLE | -0.8 | 103 | 41.7 | .2705 | .2702 | .0730 |
| MOOSE CREEK | 1 | C | POOL T. | +3.8 | 103 | 30.1 | .3261 | .2710 | .0734 |
| MOOSE CREEK | 1 | D | RUN | -0.9 | 105 | 48.6 | .2110 | .2313 | .0535 |
| MOOSE CREEK | 1 | E | RIFFLE | -1.5 | 100 | 18.0 | .3787 | .2369 | .0561 |

Macroinvertebrate Results

Despite moderate riffle embeddedness values of 33 and 38%, Mangum's (1986) analyis indicates high numbers of a moderately sediment tolerant mayfly, E. inermis, as well as sediment tolerant oligochates. Only 12% of the numbers were of taxa requiring clean interstices, although they represented 45% of the biomass. The BCI value for the samples was 100, indicating the stream was at its potential.

Fish Population Results

Table 13. Fish population estimates for a 300 meter length of Moose Creek during 1985.

| STREAM | LOCATION | SIZE CLASS | ALL TROUT | WS CUTTHROAT | OTHER TROUT | WHITEFISH |
|---|---|---|---|---|---|---|
| MOOSE CR | SITE 1 | TOT. POP. | 127 | 127 | - | - |
| - | - | 4"-5.9" | 19 | 19 | - | - |
| - | - | 6"+ | 108 | 108 | - | - |

Gold Creek

Site Description

Gold Creek is a tributary to the Burnt Fork of the Bitterroot River managed by the Stevensville Ranger District. The study site (Figures 15-16) has a drainage area of 12.7 square miles with and has no roads in the drainage but additional

road construction is scheduled for construction in 1989. Site 1 is located in T7N, R19W, NE1/4 Sec.1. The site is located in a type C channel with an overall surface gradient during summer flows of 4.4%. Site 2 at station A has a surface gradient of 0.3%, and 2.6% at station B. Two riffles, and a pool tailout were selected for study. Active channel width was 7.5-8.5 (mean=8.0) feet at the study site.

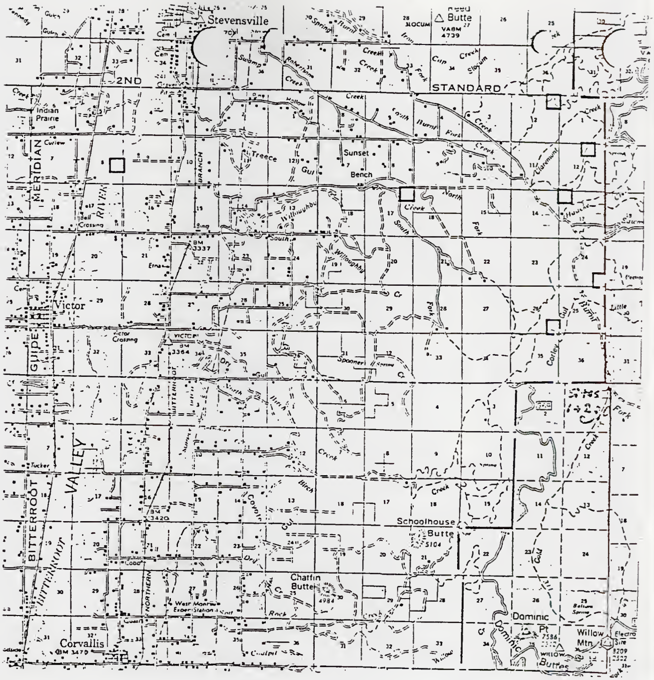


Figure 15. Location map for Gold Creek embeddedness sites.


Figure 16. - Location map of embeddedness sites on Gold Creek.

Embeddedness Results

Data for 1985 sampling of embeddedness is presented in Table 14. Values for riffles are reasonable consistant with embeddedness values of 37 and 46 percent with free matrix particle values of 12 and 16 percent. The pool tailout had a similiar embeddedness value of 37 percent, but also had a free matrix value of 25 percent.

Table 14. Embeddedness and free matrix values for 1985 samples for 2 riffles and one pool tailout on Gold Creek, Stevensville Ranger District.

| STREAM | SITE | STA. | TYPE | % GRAD. | N | % FREE | MEAN | STD.DV. | VARIANCE |
|---|---|---|---|---|---|---|---|---|---|
| GOLD CREEK | 1 | A | RIFFLE | -2.9 | 103 | 11.9 | .4598 | .2577 | .0664 |
| GOLD CREEK | 2 | A | POOL T. | +4.3 | 103 | 25.2 | .3678 | .2990 | .0894 |
| GOLD CREEK | 2 | B | RIFFLE | -0.6 | 109 | 15.6 | .3737 | .2475 | .0612 |

Macroinvertebrate Results

Invertebrate results were derived form samples at Riffle 2B, which had an embeddedness level of 37%. 47% of the biomass and and 31% of the taxa require clean interstices, while moderate or heavily tolerant taxa made up 42% of the biomass and 49% of the taxa present. Mangum (1986) considered this to be warning levels of these tolerant species. Biomass was 2.4 gm/m3 which is in the moderate range for western Montana streams.

Fish Population Results

Table 15. Fish population estimates for a 300 meter length of Gold Creek during 1985.

| STREAM | LOCATION | SIZE CLASS | ALL TROUT | WS CUTTHROAT | OTHER TROUT | WHITEFISH |
|---|---|---|---|---|---|---|
| GOLD CR | SITE 2 | TOT. POP. | 127 | 61 | 66 | - |
| " | " | 4"-5.9" | 117 | 51 | 66 | - |
| " | " | 6"+ | 10 | 10 | - | - |

## Sleeping Child Creek

Site Description

Sleeping Child Creek is a tributary to the Bitterroot River managed by the Darby Ranger District. Study site 1(Figures 17-19) has a drainage area of 65.0 square miles and study site 2 has a drainage area of 41.7 square miles. There were no roads in the study drainage prior to 1985, however road construction estimated to

total 8.5 miles has begun and is scheduled for completion in 1986. Study site 1 is located in T4N, R20W, NE1/4Sec 2. Site 1 is located in a type C channel with an overall surface gradient during summer flows of 2.7% at Site 1 Station A, and 0.3% for stations B thru E. Site 2 was 0.4%. Three riffles, two runs and a pool tailout were selected for study. Active channel width was 33-95 (mean=42) feet at the study site.

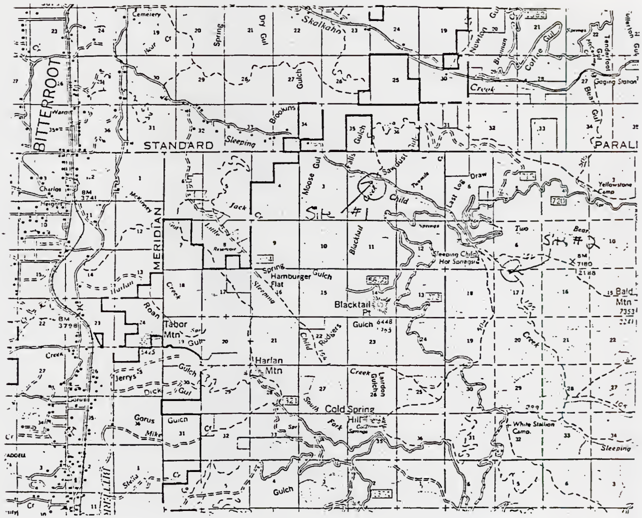


Figure17. Vicinity map for Sleeping Child embeddedness sites.

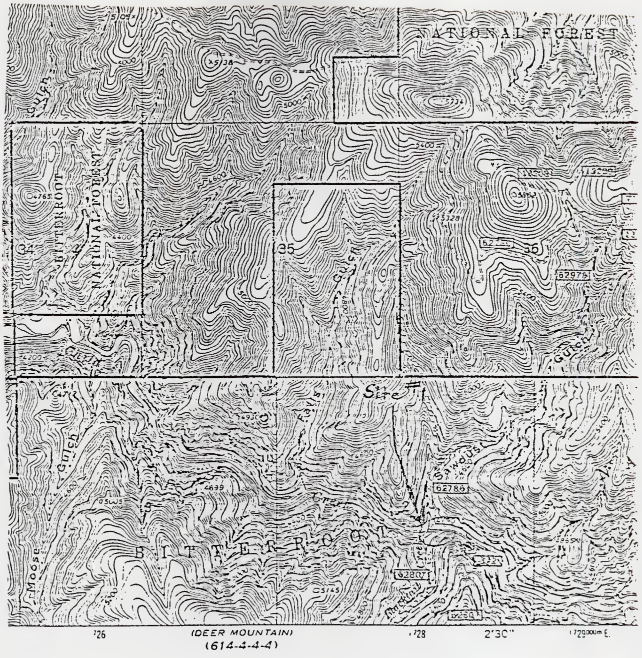


Figure 18. Location map of Sleeping Child embeddedness Site 1.

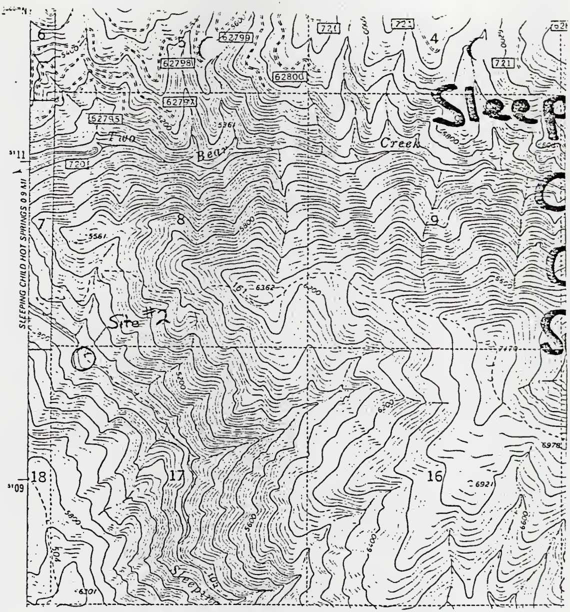


Figure 19. Location map for Sleeping Child embeddedness site 2.

## Embeddedness Results

The 1985 embeddedness and free matrix particle results are displayed in Table 16. Riffles had little embeddedness variability, with values ranging only from 37 to 42%, but free matrix values had a wider range from 10 to 22%. The two runs showed little embeddedness variability also, with values ranging from 33 to 37% embedded, and free matrix values also showing greater variability of 13 to 30%

Table 16. Embeddedness and free matrix values for 1985 samples for 3 riffles, two runs and a pool tailout on Sleeping Child Creek, Darby Ranger District.

| STREAM | SITE | STA. | TYPE | % GRAD. | N | % FREE | MEAN | STD.DV. | VARIANCE |
|---|---|---|---|---|---|---|---|---|---|
| SLP. CHILD CR. | 1 | A | POOL T. | +7.7 | 125 | 17.6 | .3867 | .2452 | .0601 |
| SLP. CHILD CR. | 1 | B | RIFFLE | -1.9 | 114 | 19.3 | .3639 | .2618 | .0686 |
| SLP. CHILD CR. | 1 | C | RUN | -0.4 | 118 | 12.7 | .3671 | .2214 | .0490 |
| SLP. CHILD CR. | 1 | D | RIFFLE | -0.8 | 106 | 21.7 | .3445 | .2390 | .0571 |
| SLP. CHILD CR. | 1 | E | RUN | -0.9 | 101 | 29.7 | .3294 | .2633 | .0693 |
| SLP. CHILD CR. | 2 | A | RIFFLE | -0.7 | 104 | 9.8 | .4191 | .2135 | .0456 |

## Macroinvertebrate Results

Mangum's (1986) assessment of the relative health of the two stations indicates that the upper station is in better condition than the lower station. Both sites had good biomass, with the lower station having 6.4 gm/m3 and the upper station having 4.5 gm/m3. The two sites have some notable habitat differences. The lower station has lower stream energy corresponding smaller average substrate size and also has considerable algae growth, apparently originating from the nutrients and/or the warmer water originating from the 'hot springs tributary'. It is highly possible that some of the nutrients may originate from the resort facility due to the closed narrow canyon and the resort's proximity to the stream. In contrast, the upper station is a high energy stream with a high diversity of habitat. This difference may explain the absence of *E. doddsi* at station 1 and its presence at station 2, and the high numbers of *E. inermis* and oligochaetes at station 1.

## Fish Population Results

Table 17. Fish population estimates for a 300 meter length of Sleeping Child Creek during 1985.

| STREAM | LOCATION | SIZE CLASS | ALL TROUT | WS CUTTHROAT | OTHER TROUT | WHITEFISH |
|---|---|---|---|---|---|---|
| SLP CHILD | SITE 1 | TOT. POP. | 308 | 308 | ~ | ~ |
| ~ | ~ | 4"-5.9" | 170 | 170 | ~ | ~ |
| ~ | ~ | 6"+ | 138 | 138 | ~ | ~ |
| SLP CHILD | SITE 2 | TOT. POP. | 110 | 110 | ~ | ~ |
| ~ | ~ | 4"-5.9" | 61 | 61 | ~ | ~ |
| ~ | ~ | 6"+ | 49 | 49 | ~ | ~ |

## Comparisons of Paired Streams

### Embeddedness

Embeddedness means for each station having a comparable station on a paired stream were compared, i.e., riffles of one stream from an undeveloped drainage were compared with riffle means of the paired stream from a developed drainage selected for comparison. F-tests were used to compare the homogeneity of variances between station means, and the appropriate T-test was then used to calulate two tailed probabilities. Table 18 summarizes the results of that analysis.

Table 18. T-Test results for embeddedness means of paired streams and stations

| Compared Stations | Results | Two tailed probability |
|---|---|---|
| Meadow riffle (Site 1, Sta A)<br>Tolan riffle (Site 1, Sta A) | Significant Difference<br>at .01 level | .000 |
| Meadow riffle (Site 2, Sta A)<br>Tolan riffle (Site 1, Sta A) | No Significant Difference<br>at .05 level | .974 |
| Meadow pool tailout(Site 2, Sta B)<br>Tolan pool tailout (Site 2, Sta A) | Significant Difference<br>at .01 level | .003 |
| Moose pool tailout (Site 1, Sta A)<br>Martin pool tailout(Site 1, Sta C) | No Significant Difference<br>at .05 level | .064 |
| Moose pool tailout (Site 1, Sta C)<br>Martin pool tailout(Site 1, Sta C) | No Significant Difference<br>at .05 level | .542 |
| Moose riffle (Site 1, Sta B)<br>Martin riffle (Site 1, Sta A) | No Significant Difference<br>at .05 level | .145 |
| Moose riffle (Site 1, Sta E)<br>Martin riffle(Site 1, Sta A) | Significant Difference<br>at .01 level | .000 |
| Moose run (Site 1, Sta D)<br>Martin run (Site 1, Sta B) | Significant Difference<br>at .05 level | .030 |

The above results indicate that there are some statisical differences between compared stations on paired streams. Although these sites are from the same morphological position in the stream (e.g. riffles), there apparently are site differences that may make each morphological position unique. This is confirmed when comparing stations of the same morphological position in the same stream where other variables have been eliminated (Table 18 ). There is variablility between compared results of paired streams in some morphological positions, however there is no clear pattern whether there are significant differences between developed and undeveloped watersheds. Where significant differences are detected, two of the higher means are from developed drainages and two are higher in the undeveloped drainages (Figures 20-21).

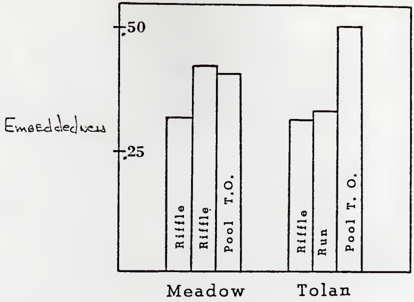


Figure 20. Comparison of embeddedness levels of morphological positions sampled in Meadow and Tolan Creek during 1985.

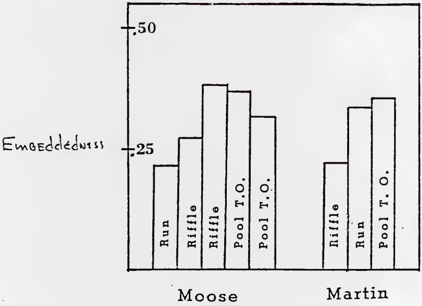


Figure 21. Comparison of embeddedness levels of morphological positions sampled in Moose and Martin Creek during 1985.

The intent of selecting streams for paired comparisons was to observe whether gross differences occurred between developed and undeveloped watersheds as a scoping process. At that time, it was recognized that individual stream and morphological differences existed that would make all but gross differences between streams difficult to interpret.

Comparisons of the same morphological postions of Bitterroot streams sampled in 1985 indicates that more embeddedness variability occurs in riffles (Figure 22) than either runs (Figure 23) or pool tailouts(Figure 24). Interestingly, Gold Creek, the only non-granitic stream sampled, had higher riffle embeddedness than did any other stream on the Forest(Figure 22).

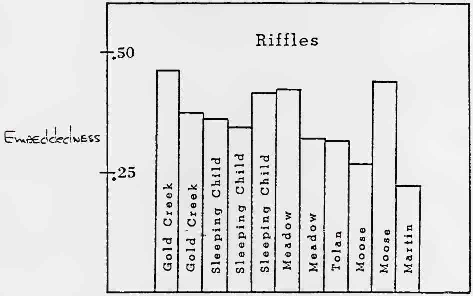


Figure 22. Riffle embeddedness for 11 stations on 6 Bitterroot National Forest streams sampled during 1985.

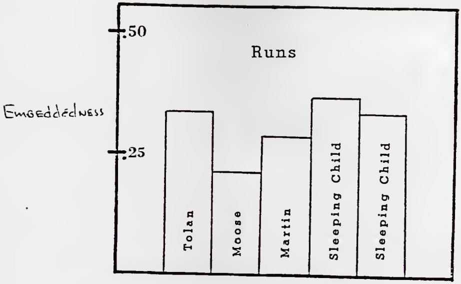


Figure 23. Run embeddedness for 5 stations on 4 Bitterroot National Forest streams sampled during 1985.

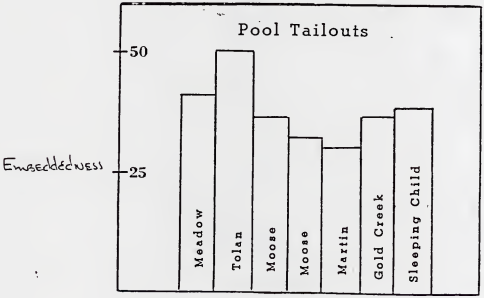


Figure 24. Pool tailout embeddedness on 7 stations on 6 Bitterroot National Forest streams sampled during 1985.

A simple regression was developed to evaluate the strength of the relationship between embeddedness values and the percentage of free matrix particles in the same sample. A r2 value of .72 was evidence that a good relationship exists between the two values and when the total data from the Lolo, Deerlodge, and Bitterroot data were combined, an even stronger value (r2=.81) exists (Figure 25).

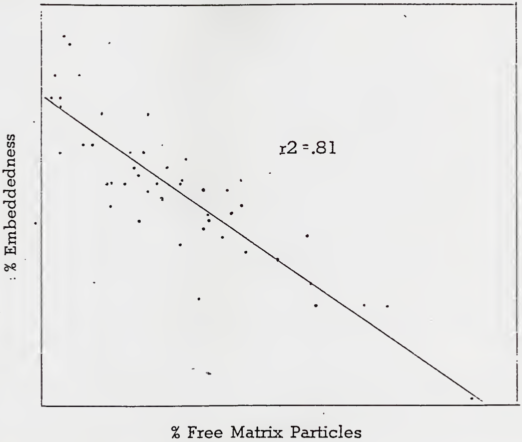


Figure 25. Relationship between embeddedness and free matrix particles found on the Bitterroot, Lolo, and Deerlodge National Forests.

Macroinvertebrate Community Structure Related to Embeddedness or Free Marix

Using a multiforest combination of 20 invertebrate sampling stations, of which 7 stations were on the Bitterrroot, a series of linear regressions were developed to test the relationship of embeddedness and free matrix particle frequency with the composition of the invertebrate community. Relationships were developed for invertebrate groups requiring like habitat, i.e. taxa requiring intersticial spaces taxa utilizing top of substrate, and a sediment tolerant group. Seperate relationships were developed for numbers of taxa in each group, community numbers in each group, and biomass in each group. Table 19 displays the r2 values for each relationship.

Table 19. r2 values for linear relationship between embeddedness, free matrix particles and invertebrate community structure for 20 sample stations on the Deerlodge, Lolo, and Bitterroot National Forest.

| Particle Measurement | Invertebrate Measurement | r2 value |
|---|---|---|
| Embeddedness % | % Taxa are Sediment Tolerant | .05 |
| Embeddedness % | % Community Numbers are Sed. Tolerant | .21 |
| Embeddedness % | % Biomass is Sediment Tolerant | .04 |
| Embeddedness % | % Taxa require Intersticial Spaces | .00 |
| Embeddedness % | % Comm. Numbers require Interstic. Space | .07 |
| Embeddedness % | % Biomass require Intersticial Spaces | .08 |
| Embeddedness % | % Taxa use Top of Substrate | .05 |
| Embeddedness % | % Community Numbers use Top of Substrate | .14 |
| Embeddedness % | % Biomass use Top of Substrate | .32 |
| Free Matrix % | % Taxa are Sediment Tolerant | .06 |
| Free Matrix % | % Community Numbers are Sed. Tolerant | .22 |
| Free Matrix % | % Biomass is Sediment Tolerant | .04 |
| Free Matrix % | % Taxa Requiring Interstical Spaces | .00 |
| Free Matrix % | % Comm. Numbers Req. Interstic. Space | .02 |
| Free Matrix % | % Biomass Requiring Intersticial Space | .07 |
| Free Matrix % | % Taxa Using Top of Substrate | .17 |
| Free Matrix % | % Community Numbers use Top of Substrate | .24 |
| Free Matrix % | % Biomass Using Top of Substrate | .22 |

These weak r2 values do not support the linear relationship between invertebrate community structure as defined and the quantification of embeddedness and the availability of free matrix particles. Possible explanations are presented in the Discussion section of this report.

Fish Population Versus Existing Embeddedness

Simple regressions were developed for embeddedness and fish population data. Fifty three regressions were developed to analyze species and size groups of fish against run, riffle, or pool tailout embeddedness. R-squared values were usually extremely low indicating no significant relationship. There was one or two R-squared values exceeding .5, however the sample size of these test were limited to only three or four observations and therefore cannot be considered to be a valid test.

## DISCUSSION

The first year of data indicate that the embeddedness and free matrix particle measurements are feasible indicators of substrate sedimentation on the Bitterroot National Forest. A variety of embeddedness and free matrix particle values ranging from .21 to .51 and 4% to 49% suggest that there is enough variability between samp stations to detect differences. The embeddedness and free matrix particle obtained on the Bitterroot National Forest in 1985 indicate considerable natural variability within streams of different and even the same morphological position. As expected, there is variability between streams.

Embeddedness means for all sampled riffles, runs, and pool tailouts of .35, .30, and .38 respectively do not clearly suggest that morphological position in the stream influences stream embeddedness, nor do the free matrix particle values of 20%, 28%, and 20% respectively. Variability of embeddedness between stations of the same morphological position on the same stream suggest that each sampling station should

be evaluated independently over time for changes in embeddedness values, although a or several of the sampling stations on the same stream may have the potential to change if sediment transport rates were to change. The similiarity of the changes that occur within a stream will be evaluated in future analysis.

Burns(1984) found significant embeddedness differences between groups of heavily developed and undeveloped or partially developed tributaries of the South Fork of t Salmon River in Idaho, a granitic drainage. Mean embeddedness values for partially undeveloped tributaries was .24 (range .19-.30), while heavily developed drainages had a mean value of .44(range .36-.50). Although Burns did not describe morphological position sampled, the Bitterroot embeddedness values are within the ranges described by Burns for the South Fork tributaries. However, the upper value of embeddedness for undeveloped Bitterroot drainages appear to be higher( e.g Tolan=.51, Gold=.46, Moose=.38) than those found in the South Fork. Burns(1985) found embeddedness values in basalt drainages to range from .12 to .46., suggesting that high embeddedness value can occur in non-granitic streams. This possibility i demonstrated in Gold Creek where values as high as .46 were observed in this undeveloped drainage. Kelley and Dettman (1980) measured embeddedness values in a reach of Lagunitas Creek, California ranging from .17 to .69 (mean=.42) in glides (runs) and from .10 to .48 (mean=.24) in riffles. They found a strong correlation ($r2$=.85) between riffle and glide embeddedness and steelhead trout density.

Embeddedness values observed on the Bitterroot should not be compared with embeddedness values cited in literature where surface embeddedness is the measured parameter. We strongly suspect that surface embeddedness values are substantially lower than values obtained for embeddedness values on the Bitteroot. We propose to evaluate this relationship in 1986 monitoring. There are many Bitterroot examples where free matrix values would suggest that the surface of the substrate was void o fines, however we would record moderate embeddedness. This is because excavation below the surface layer of substrate is commonly necessary to reach the substrate level where all further particles are completely embedded. With our methodology partially embedded material is always encountered and recorded, therefore raising t mean embeddedness value that would be found with surface material only. We expect t be able to develop the correlation between surface embeddedness and excavated embeddedness in next year's sampling.

We did establish a strong correlation ($r2$=.81) between embeddedness values and percent free matrix particles (Figure 25). This strong correlation suggests that a monitoring method of only sampling free matrix particle occurance may be able to be converted to embeddedness values with little error. Monitoring only free matrix particle may be appropriate for some situations where there is a need to approximat that substate sedimentation is within certain limits. 1985 sampling on the adjacen Lolo National Forest found a good correlation between very fine sediment (.21-.83 mm) and both embeddedness and percentage free matrix particles ($r2$=.73 for each)(Appendix) suggesting that either measurement may be used to assess the composition of substrate made up of very fine sediment. These measurements are commonly used to express potential egg survival or fry emergence success.

A high percentage free matrix particle value suggests considerable intergravel interstices available for some aquatic insect species and intersticial use by juvenile and small salmonids. Campbell and Neuner (1985) found intersticial use by rainbow trout up to 150 mm (6 inches) during winter days. Edmundsen, et.al. (1968) found similiar behavior and found fish up to 15 cm deep in the substrate. Giger(1973) observed similiar behavior for brown trout. We believe that the free

matrix value is important in describing the availability of intersticial voids available for both insects and small salmonids that is not available when attemptin to interpret methods using substrate composition values such as those obtained by core sampling. We expect there may be a correlation between surface embeddedness values and percentage free matrix values and will investigate this relationship during the 1986 field season.

The low r2 values for the invertebrate/sediment linear relationships could have several possible explanations. Invertebrate populations could be considerably different in community structure from one drainage to another, as the samples represented differences in geologic type, stream order and site specifically differ in stream gradient. In addition, some sampling error would be expected because it was impossible to sample invertebrates exactly over the same sites as embeddedness because the exact site was disturbed by excavating for the embeddedness evaluations However, an effort was made to sample as closely as feasible to reduce this error. We do know, however, that there is some heterogenity among sample stations, even wh the stations have been chosen and delineated for homogenity. This potential proble should have been minimized, however, by the 5 seperate subsamples collected for eac station sample. These subsamples were frequently collected from sites intermixed with the embeddedness sample areas. There is the potential that invertebrate taxa assigned to intersticial spaces have other substitute ecological niches or have bee wrongly assigned to this ecological niche. We intend to analyze the relationship of individual species occurance that have very specific habitat niches against embeddedness levels. Suggested species include oligochaetes, chironomids, and Ephemerella doddsi.

The lack of any relationship between existing embeddedness and existing fish populations examined in 1985 suggest that other environmental factors may be sufficiently different to mask any effect that sediment may have on the population. We intend to quantify the other habitat variables on the fish sample sections in 1986.

OTHER BITTERROOT MONITORING

During 1985 40 boulder clusters were placed in a one mile reach of the East Fork Bitterroot River. At the request of the Montana Department of Fish, Wildlife and Parks, monitoring of streambed elevations was initated. Permanent elevation reference points were established and a linear transect of the thalweg was established through the length of the project area, with locations of each boulder cluster noted along the profile. Establishing this profile was a time consuming effort that prevented gathering other baseline habitat data that would have been desirable to determine the degree the habitat improvement project improves fish utilization of the reach. The profile monitoring is to resolve the issue of whethe this boulder project would aggrevate accumulation of bedload in the project area. anticipate remonitoring this profile in 3-5 years.

RECOMMENDATIONS FOR MONITORING IN 1986

1. Continue existing stations as baseline and to assess annual individual site variability and to evaluate changes that may occur as a result of land management activities. Add additional sites in the vicinity of existing stations as time perm

to improve the ability to detect trends in light of the individual variability of sites having similiar morphological position.

2. Add other stations as manpower and time permits. Added sites should be considered for Daly Creek (to complete cooperative study with MDFWP) and St. Clair Creek (to monitor vermiculite mine). Priority should be given to establishing monitoring stations on at least one other stream draining belt soils.

4. Develop correlation between embeddedness measurements used by the Bitterroot and surface embeddedness measurements commonly cited in literature by completing a estimate of surface embeddedness at each embeddedness hoop measurement site before excavation begins. This will make interpretations to the literature related to fis consequences more feasible.

5. Develop correlation between surface embeddedness relationships and percentage fr matrix particles.

6. Quantify habitat parameters on fish shocking reaches to better explain variablility of fish populations between streams. Parameters expected to be measur include pool frequency and quality, cover quanity and type, specific conductance, invertebrate abundance and diversity.

7. Encourage the establishment of hydrologic stations on monitored streams to measu both streamflows and bedload movement on a continous basis, especially during high flow events. This can be used to quantify sediment being transported through the embeddedness stations, which will improve our knowledge of the relationship of sediment transport to sediment deposition.

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# EMBEDDEDNESS EVALUATIONS

To determine sediment deposition
as an indication of fish habitat condition.

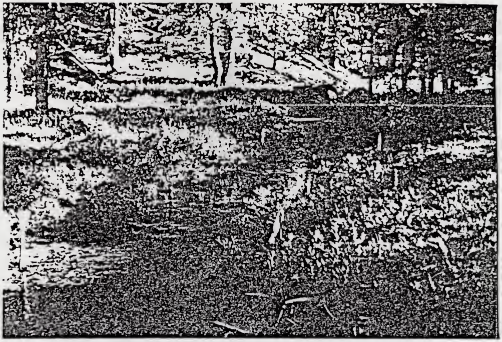


Figure 1. Sites to be sampled may be riffles, pool tailouts, or runs such as the above station. Boundaries of each station are documented photographically, using permanent reference points and boundary stakes. A gradient profile is developed for each site.

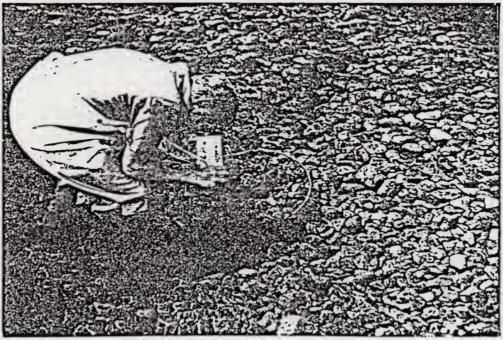


Figure 2. A 2-foot diameter hoop is randomly thrown at each station, several times, and embeddedness of each particle within the hoop is measured. The hoop is rethrown until at least 100 particles are measured.

Figure 3. Each particle greater than 2 inches in diameter is extracted from the streambed within the hoop.

Figure 4. Using a special measuring device, each particle is held along the plane of embeddedness, and the total diameter of each particle perpendicular to the plane of embeddedness is measured as well as the length of each particle that is embeddedness recorded.

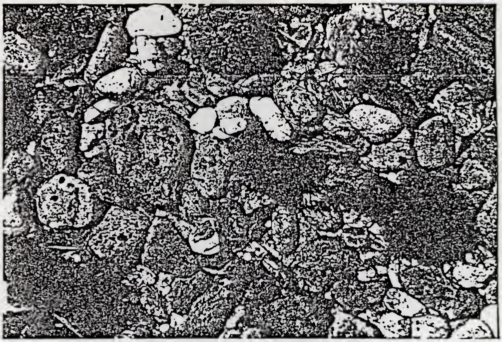


Figure 5. Example of substrate with low embeddedness. Some of these particles are only in contact with other larger substrate and are termed free matrix particles.

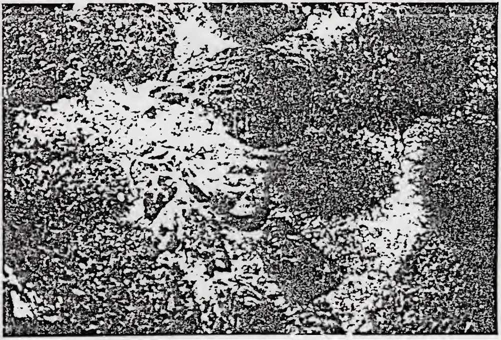
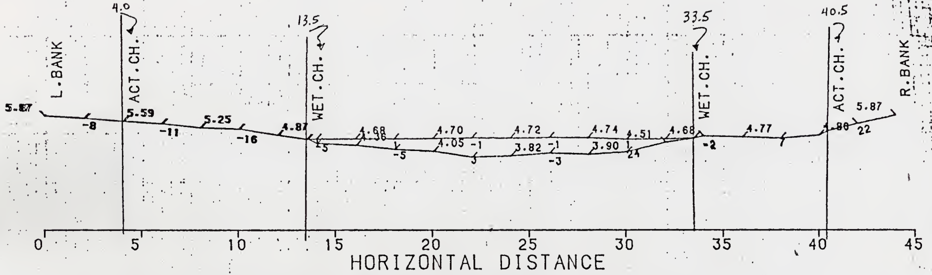


Figure 6. Example of substrate with high embeddedness. Note that a substantial portion of each particle is covered with sediment. There are no free matrix particles present.

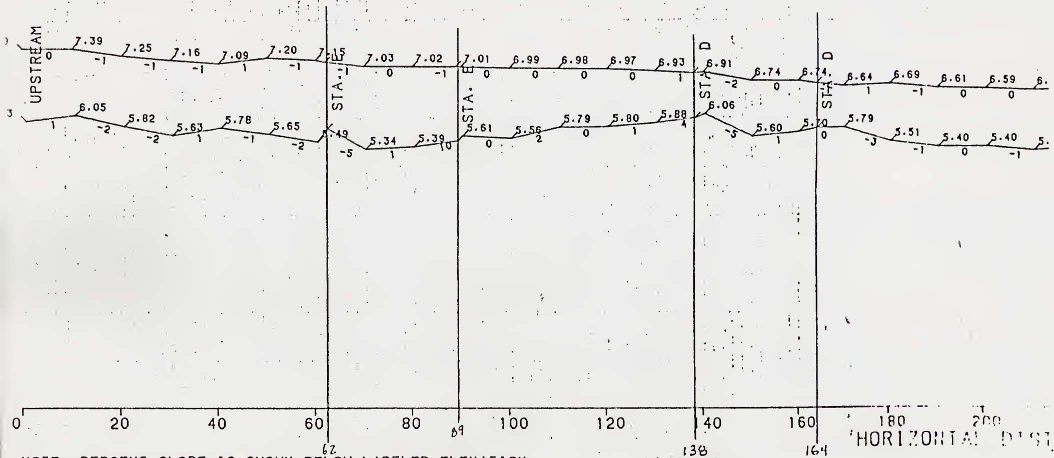



NOTE: PERCENT SLOPE IS SHOWN BELOW LABELED ELEVATION

USFS R1 GEOMETRONICS 5 FT/IN.HOR 5 FT/IN.VERT 12/20/85

SC1AX Sleeping Child Site 1 Station A

# CROSSECTION PROFILE (EXAMPLE)




NOTE: PERCENT SLOPE IS SHOWN BELOW LABELED ELEVATION
USFS R1 GEOMETRONICS 20 FT/IN.HOR 2 FT/IN.VERT 12/20/85
SC1FL Sleeping Child Site 1

LINEAR PROFILE (EXAMPLE)